REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	January 2, 1998	Final Report (09 March 1994-31 Dec. 1996)

4. TITLE AND SUBTITLE

Deep Ocean Unmanned Vehicle Program

5. FUNDING NUMBERS

N00014-94-C-0102

6. AUTHOR(S)

Christopher von Alt and Michael Purcell

7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(ES)

Woods Hole Oceanographic Institution
Applied Ocean Physics and Engineering Department
98 Water Street
Woods Hole, MA 02543-1053

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAMES(S) AND ADDRESS(ES)

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

a. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited

12. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Long Term Goals:

To collaborate with the Office of Naval Research, the Naval Oceanographic Office, and the National Science Foundation to overcome deficiencies in robotic vehicle systems which are being used to perform survey operations in both shallow and deep water.

14. SUBJECT TERMS	15. NUMBER OF PAGES
deep sea vehicles, tow cable system technology, and vehicle dynamics	4
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

Header Information:

Principal Investigator:	Christopher von Alt
Contract Title:	Deep Ocean Unmanned Vehicle Program
Mailing Address:	Woods Hole Oceanographic Institution MS # 10 Woods Hole, MA 02543
E-mail Address	cvonalt@whoi.edu
Phone Number:	508-289-2290
Fax Number:	508-457-2104

Narrative Documentation

Long Term Goals:

To collaborate with the Office of Naval Research, the Naval Oceanographic Office, and the National Science Foundation to overcome deficiencies in robotic vehicle systems which are being used to perform survey operations in both shallow and deep water.

Approach:

Strong cooperative links between Universities, Industry, the Office of Naval Research, and the Naval Oceanographic Office provide a means of identifying and overcoming deficiencies in undersea robotic systems which are operated by NAVOCEANO. Some deficiencies require a research and development effort to be corrected. In other cases, the use of commercially available technology is more appropriate and affordable. By approaching the problem from this perspective, we have established an affordable means of providing the Naval Oceanographic Office with timely solutions to survey problems which they encounter in their support of Fleet objectives.

Scientific and Technical Accomplishments

Focus areas of this proposal include: Tow cable system technology, and a study of vehicle dynamics

1. During towing operations, ship motions induce axial tow cable motions which are then transmitted to the towed robotic vehicle. These motions result in vehicle heave that may then lead to pitch and roll motions and dynamic tensions in the cable. These motions disrupt the video and acoustic data gathering capabilities. The dynamic tensions caused by these motions may lead to cable failure by creating snap loading conditions or combining with the static load to exceed the ultimate cable strength. Motion compensating systems, both passive and active, have been designed to minimize the transfer of ship motions to tow cables and ocean drilling pipe strings. These systems have been successful in reducing dynamic loading and induced motions.

Using computer programs developed at WHOI and MIT with ONR support, and then modified by OSL, OSL has analyzed towing of deep sea vehicles with no compensation, with a passive bobbing hydraulic crane compensator, and with an active hydraulic bobbing crane compensator. Variables in the analyses included depth, wave (sinusoidal) height and frequency, compensator stiffness and damping, tow speed, and crane geometry. With no compensation, large dynamic tensions and vehicle heave motions occur at depths of 750 to 2500 meters in wave periods of 6-10 seconds. The dynamic tensions will exceed the static weight of the vehicle and deployed cable for larger waves. The vehicle heave ranges up to 2.25 times the ship heave, making it very difficult to stay near the bottom for good video and sonar performance. The analyzed bobbing crane compensator eliminates the peak tensions and heave motions that occur without heave compensation. This passive compensator is effective at reducing both vehicle motion and dynamic tensions up to 75% of uncompensated values in shallower depths and shorter wave periods. As depth (>3000 m) and wave period (>12 s) increase, the passive system becomes less effective at reducing vehicle motion because of inherent stiffness in the bobbing crane design. An active system is required to minimize tow vehicle heave motions at full ocean depth.

Working with a crane manufacturer, OSL was tasked to develop a cost effective bobbing crane compensator and integrate it into the TOSS system. After developing a specification and obtaining bid results, it was determined that this approach is too complex and hence is not cost effective or reliable. Because of concerns of this nature, a decision was made not to invest in a heave compensation system. As a result, a modification to this program was requested in October 1996. The motion compensation system has been replaced with an overboard handling system. Delivery and system integration are expected to take place during this fiscal year.

2. During the 1993 TOSS missions, vehicle heave-induced pitching and rolling motions were observed. This suggests that the vertical center of drag is not aligned with the vehicle center of gravity. The full benefit of the advanced sensor suite will not be realized without a fully stable vehicle. OSL evaluated and corrected stability problems during a series of experiments which were conducted in the clear water tank at Stennis Space Center. This was accomplished by determining the vertical center of drag and identifying modifications that provided proper alignment with the vehicle center of gravity. Studies to improve the imaging capabilities of the system were also conducted at this time.

3. Reliable operation of the cable handling system is critical to meeting mission objectives at sea. The 150 horsepower hydraulic system used with the TOSS vehicle had a history of short term operation followed by long inactive periods. This type of operation in the shipboard environment probably leads to more problems than continuous operation would. Prior to the 1994 TOSS missions, the cable handling system was overhauled to ensure reliable operation. Our research included addressing problems experienced during the 1993 missions with the level wind and traction winch brake release, replacing filters, hoses, and oil, and adding new sensors. The

sensor upgrade involved replacement of existing cable related sensors and electronics, and addition of sensors to monitor the hydraulic pressures in the cable handling system. The new sensor electronics were integrated with the TOSS control computer to allow multiple displays and logging of the sensor data.

Impact on Science

The primary impact on science involved the development of the computer simulation program. We have determined that it is more cost beneficial to use a slack tensioner to compensate the vehicle's motion than to use a passive or active nodding boom motion compensator. These results have been published and the scientific community is aware of this information.

Transitions Accomplished and Expected

This contract represents the transition of research funded by ONR to the Fleet. All of the goals of this research have been completed and transferred to the Naval Oceanographic Office.

Relationship to Other Projects

none

List of Publications etc.

Papers published

Purcell, M., Forrester, N., "Bobbing Crane Heave Compensation for Deep Towed Fiber Optic systems" SNAME, New England Section Fiftieth Anniversary Proceedings May 6-8 1994, Woods Hole, MA

Books published - none

Summary Information:

R&T Number :	3211056
Contract/Grant Number:	N00014-94-C-0102
Contract/Grant Title:	Deep Ocean Unmanned Vehicle Program
Principle Investigator:	Christopher von Alt
Mailing Address:	Woods Hole Oceanographic Institution MS # 10 Woods Hole, MA 02543
Phone Number:	508-289-2290
Fax Number:	508-457-2104

E-mail Address cvonalt@whoi.edu

a.	Number of patents filed	0
b.	Number of patents granted	0
c.	List of Honors/Awards/Prizes for Contract Grant Employees	0
d.	Total number of Graduate Students and Post Docs Supported	0
e.	Total number of Degrees Granted	0
f.	Transition results	None
g.	Percentage of funds sent to other organizations	None